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ABSTRACT

Research has shown that girls and boys begin at equal levels of performance in mathematics and science, but that during the middle school years differences have been observed in both science achievement and science attitudes of males and females. It appears that once science becomes an option for females, they often do not select science experiences. The purpose of this literature review was to analyze research dealing with the factors influencing female retention in the sciences. These factors were considered from personal, sociological, and educational perspectives, with the intention of making people more aware of the influences which they may have on the future education of females. The studies cited in this project are arranged in alphabetical order and are annotated. These studies reveal several personal (biological, individual self-concept, and locus of control), social (stereotyping and the influence of significant others), and educational (classroom environment and science experience) variables which are responsible for this lack of female participation in the sciences. (TW)

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Factors Which Influence A Female's Decision To Remain In Science

by

Kristie Kurth

Exit Project-S 591

Dr. DuVall

June 11, 1987

SE 048 751

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INTRODUCTION

The continual decline in Scholastic Aptitude Test (SAT) scores over the past ten years (National Science Foundation, p.88) has brought with it a public awareness of what is taking place in education. According to the National Assessment of Educational Progress (NAEP) all age groups have experienced significant declines in science achievement.(National Science Foundation, p.88) Not only did the NAEP show that there have been declines in science achievement but also in student attitudes concerning science.(NAEP p. 8) Even more important is the fact that student attitudes concerning science have been found to become more negative as students get older.(NAEP, p.9) Studies have also revealed that twice as many college-bound senior boys have taken three years of physical science.(National Science Foundation, p. 31) This disproportionate ratio of males to females is present in many upper level science classes.(Keys and Ormerod, 1976) Skolnick, Langbort, and Day claim that,

> "We stand to enrich the entire world of mathematics and science by asking not why girls can't learn these subjects but why they aren't the sorts of subjects girls want to learn."(p. 2)

Research has shown that girls and boys start out at equal levels of performance in math and science. It is during the middle school years, early adolescence, when we first begin to see differences in both science achievement and science attitudes of males and females.(Maccoby and Jacklin, 1974; Baird, et.al., 1984) Once science becomes an option for females it has been found that females have chosen to opt out of science.

What factors influence the decision of females not to choose science as a future endeavor? Research offers a personal, sociological, and educational explanation to this problem facing our adolescent females.

STATEMENT OF THE PROBLEM

With the advancement of technology in our present society we must train all capable students in the areas of science and technology. Evidence exists that the science field is currently a male-dominated field, not because they are more capable, but because they are more interested. Educators and parents must recognize the factors that influence females to not choose science as a career option.

PURPOSE

The purpose of this study was to analyze the research dealing with the factors influencing female retention in the sciences. These factors were looked at from a personal, sociological, and educational perspective, with the intention of making people aware of the infuences which they may have on the future education of females.

ORGANIZATION OF THE STUDY

Due to the fact that several studies cited in this project covered more than one specific variable which influenced the achievement of females in science, the annotations are arranged in alphabetical order so as to eliminate the duplication of the same annotation under several headings.

The general organization of the study was to look first at the personal factors which influence females science choices. Personal factors included biological factors and psychological factors. Sociological factors were then looked at to determine their influence on females. Sociological factors included stereotyping of science by students and the availability of role-models. Finally, the educational factors were investigated. Educational factors included expectations of significant others, teacher behaviors, and student experience.

LIMITATIONS OF THE STUDY

This study does not attempt to look at the socieconomic factors that influence science achievement and science attitudes. Also included in this project were several studies which dealt with research on math achievement. These studies were included because of the close relationship that has been found to exist between math and science achievement.

GLOSSARY

achievement -- accomplishment of proficency of a person in a given skill or body of knowledge or seen as progress in school. (Good, 1973:7)

achievement test -- a test designed to measure a person's knowledge, skill, understanding, etc. in a given field in school. (Good, 1973:594)

affect -- the feeling component of mental life as contrasted with cognitive, or thinking elements of mental activity. (Good, 1973:19)

aptitude -- characteristics of an individual's ability to acquire proficiency in a given area. (Good, 1973:37)

aptitude test -- a device taht is used to assess a combination of native and acquired abilities which are considered indicative of future performance. (Good, 1973:595)

attitude -- the predisposition or tendency to react specifically towards an object, situation, or value, must be inferred from overt behavior. (Good, 1973:49)

attitude test -- a test to measure the mental and emotional set or pattern of likes and dislikes held by an individual or group. (Good, 1973:595)

coefficient of multiple correlation (multiple regression) -- a number indicating the degree of relationship between a criterion or dependent variable and the weighted sum of a number of independent variables. (Good, 1973:112)

cognitive intelligence -- the mental functioning involved in perceiving, knowing, and understanding. (Good, 1973:310)

continuing motivation -- the desire to look further into a topic outside of the classroom experience. (Pascarella,et.al., 1981:440)

empirical study --study done that is derived from or based on experience or observation. (Good, 1973:210)

infralogical grouping -- considers spatial and temporal relationships within continuous systems; objects must be present. (Treagust, 1980:91)

intelligence quotient (IQ) --a measure for expressing level of mental development in relation to chronological age; obtained by dividing the mental age, as measured by a general intelligence test, by the chronological age and multiplying by 100. (Good, 1973:214)

logical grouping -- considers classifications and relationships between sets of discrete objects. (Treagust, 1980:91)

longitudinal study -- a study that follows a case or group of cases over a period of time. (Good, 1973:565)

meta-analysis -- statistical analysis of a large collection of analysis results from individual studies for the purpose of integrating the findings. (Mitzel, 1982:1614)

multivariate analysis -- statistical procedure that is designed to describe, interpret and predict the behavior of two or more variables that change or interact simultaneously. (Good, 1973:30)

path analysis -- strategy for understanding causal processes through the analysis of correlational data. (Mitzel, 1982:1382)

role model -- the behavior patterns of functions expected of or out by an individual in a given social contex, (Good, 1973:502)

self-concept -- the individual's perception of himself as a person, which includes his abilities, appearence, and other phases of daily living. (Good, 1973:543)

social desirability -- adimension for describing the attribute of a personality statement or personality inventory item which indicates the desirability of endorsing the statement or item as true or not true of a subject. (Good, 1973:539)

socialization --process of bringing the individual, probably a child, to understand and accept customs, standard traditions, and the culture of the group in which he is a member. (Good, 1973:543)

spatial visualization-- visual relations of objects in space as they are visually manipulated. (Good, 1973:643)

ANNOTATIONS

Alvord, David J., and Lynn W. Glass. "Relationships Between Academic Achievement and Self-Concept" Science Education 58 (1974): 175-179.

The purpose of this study was to look at science achievement and its relationship to self-concept. Science achievement was measured using the information from the National Assessment of Educational Progress. Self-concept was measured using the "Self Appprаisal Inventory". The inventory was made up of four subscales. The four subscales were general, family, peer group, and scholastic. Alvord and Glass found that a significant positive correlation existed between a student's scholastic self-concept and their achievement in science at all three grade levels. The home environment was found to have a significant positive correlation with science achievement at grade 4 and 7. Peer group influence affected science achievement only at the fourth grade level.

Baird, J. Hugh, Reuven Lazarowitz, and Verl Allman. "Science Choices and Preferences of Middle and Secondary School Students in Utah" Journal of Research in Science Teaching 21 (1984): 47-54.

The researchers in this study sought answers to two questions. The questions were, "What science classes do junior and senior high school students prefer and choose?" and "Are their preferences and choices related to any specific identifiable factors?". The specific factors looked at in this experiment were, a) the type of school setting (urban, suburban, rural), b) grade level, and c) gender. 1855 junior and senior high school students were asked to list, in order of preference, the five science subjects they would like to study. The most preferred subjects were zoology, human body and health, and astronomy. The study also found that there were preference differences among the three factors studied. Urban and rural students were found to have the same preferences. Suburban students were found to have a higher preference for general science, general biology, chemistry and ecology. Several developmental trends for subject preference were identified in the study. The study also found girls with a higher preference for zoology, human body and health, ecology, and botany. Boys preferred the subjects of astronomy, chemistry, physics, atomic structure, and energy.

Benbow, Camilla Persson, and Julian C. Stanley. "Sex Differences in Mathematical Ability: Fact or Artifact?" Science 210 (1980): 1262-1264.

Benbow and Stanley suggested that the reason why girls take fewer math courses is because of their lower developmental level of mathematical reasoning. Information gathered from the Study of Mathematically Precocious Youth (SMPY) was used to investigate their hypothesis. From their study they found that a large sex difference in mathematical ability was observed in every talent search. They also found that girls and boys had equal verbal ability. Benbow and Stanley emphasized that the girls and boys in this study did not differ in their experience in mathematics. Therefore, they concluded that there must be a biological difference that exists between males and females in mathematical reasoning ability.

Benz, Carolyn R., Isobel Pfeiffer, and Isadore Newman. "Sex Role Expectations of Classroom Teachers Grades 1 - 12." American Educational Research Journal 18 (1981): 289-302.

Benz, Pfeiffer, and Newman looked at teachers' sex role expectations of students who differed by sex, grade level, and achievement. An altered form of the Bem Sex Role Inventory was used, called The Teacher Sex Role Perception Inventory. Responses from 70 teachers of grades 1 - 12 were used in a multiple regression analysis of the data. It was found that high achievers were more likely to be classified as androgynous. It also was found that high achieving males were likely to be classified as masculine sex types. High achievement was found to be negatively related to teachers feminine sex role expectations. In general, achievement was found to be the greatest predictor of teachers sex role expectations. Student sex and grade level were unrelated to teacher expectations.

Bock, Darrell R., and Donald Kolakowski. "Further Evidence of Sex-linked Major-Gene Influence on Human Spatial Visualizing Ability." American Journal of Human Genetics 25 (1973): 1-14.

Bock and Kolakowski proposed that the gene for spatial ability is X-linked and hypothesized what the outcome would be based on typical inheritance patterns of X-linked genes. Parents of children twelve years old and older from a midwestern suburban community were used in the study. Bock and Kolakowski found a pattern similar to what they expected to find with a recessive X-linked gene. The father/son correlation was near zero, the father/daughter and mother/daughter correlation were about the same, and the mother/son correlation was higher than the mother/daughter correlation.

Brush, Lorelei R. "Avoidance of Science and Stereotypes of Scientists." Journal of Research in Science Teaching 16 (1979): 237-241.

Brush wanted to identify just how negative students attitudes are about scientists and the relationship these negative attitudes have on science class enrollment. Brush also wanted to examine the relationship between the students self-image and their stereotype of scientists. A comparison was then made between the stereotypes students were found to hold of a writer and a mathematician. To determine how negative or positive these stereotypes were a social desirability score was figured for each students response. The results found each occupation to be close to the positive end in desirability, but the writer was found to be more positive than the mathematician. Brush also found that physical science majors found the mathematician to be slightly more positive than other majors. Brush did state that social desirability is not a very strong factor in determining course selection. Brush also found that the students self-image related strongly to the stereotype they held and could be used as a predictor for course enrollment.

Doran, Rodney L., and Burt Sellers. "Relationship Between Students' Self Concept in Science and Their Science Achievement, Mental Ability, and Gender." Journal of Research in Science Teaching 15 (1978): 527-533.

The purpose of this study was to investigate the relationship between students' self-concept and their mental abilities, gender, and science achievement. The Self Concept in Science Scale was used to measure the self-concept of students in science. A positive relationship was found between students achievement in biology and their self-concept in science. A positive correlation was also found between self-concept and measured process achievement and mental ability. No relationship was found between self-concept in science and the sex of the student. Doran and Sellers concluded that the higher the level of science achievement, the higher the level of a student's self-concept in science.

Entwhistle, N.J., and D. Duckworth. "Choice of Science Courses in Secondary School: Trends and Explanations." Studies in Science Education 4 (1977): 63-82.

Entwhistle and Duckworth examined the research available to find out what influenced students choice of specializing in a particular career. Following a very thorough review of the literature Entwhistle and Duckworth found that students decisions are most likely to be affected by the opportunities provided by the educational system that they are in. Factors which were found to influence student choices were 1) early specialization, 2) less interest in science, and 3) science stereotype. Thus, it was concluded that a delayed specialization would help encourage more students in science, especially females. Science courses should also be more people-oriented to counter the sex stereotype of science. Entwhistle and Duckworth also suggested reducing the complexity of the physical sciences.

Erickson, Gaalen L., and Lynda J. Erickson. "Females and Science Achievement: Evidence, Explanations, and Implications" Science Education 21 (1984): 63-89.

Erickson and Erickson looked at the findings from a science assessment project in British Colombia dealing with sex-related differences in science achievement. The study showed that boys outscore girls in the areas of scientific knowledge and the application of scientific knowledge, especially in the physical sciences. However, there were no sex-related differences in the areas of understanding the logic and processes of scientific reasoning. Two explanations were offered for the performance differences between males and females: a biological and a sociological explanation. Educationally Erickson and Erickson suggested that girls should be provided with science experiences, both in the classroom and outside the classroom, to help motivate them toward science achievement.

Eshiwani, George S. "A Study of Women's Access to Higher Education in Kenya: With a Special Reference to Mathematics and Science Education." ERIC Document, 1983, ED 247 781.

Eshiwani conducted a study which compared the math and science achievement of women in higher education. Special attention was given to the type of school from which the women came as to whether it was a coeducational or a single-sexed school. Eshiwani found that sex-role stereotyping was more prevelant in coeducational schools than in single sex schools. Eshiwani claimed that primary schools are to blame for assuming that boys and girls have the same experiences and are therefore taught the same. Eshiwani claimed that it is this assumption that widens the science gap between boys and girls.

Fennema, Elizabeth, and Julia Sherman. "Sex-Related Differences in Mathematics Achievement, Spatial Visualization, and Affective Factors." American Educational Research Journal 14 (1977): 51-71.

The main goal of this study was to look at any sex differences which may arise in mathematics achievement while controlling the previous experience of students in mathematics. A second goal was to establish information concerning other variables which may be associated with mathematics achievement. The cognitive variables of math achievement, verbal ability, and spatial visualization were investigated. The affective variables of attitude toward success in mathematics, perceived attitude of significant others toward mathematics, motivation in mathematics, confidence in learning mathematics, and usefulness of mathematics were also investigated. In order to investigate the relationship of experience to achievement the variables of number of mathematics courses taken and the amount of extracurricular math activities were also looked at in this study. Fennema and Sherman found that when students with similar ability and experience were compared the differences between male and female mathematics achievememt disappeared. The findings suggested that sociocultural factors play a role in mathematics achievement.

Fox, Lynn H. "Women and the Career Relevance of Mathematics and Science." School Science and Mathematics 26 (1976): 347-353.

Fox looked at the research that was available addressing the problem of girls lack of achievement and career attainment in the fields of math and science. Fox addressed the fact that women who are talented in these areas still do not elect to pursue these careers. Fox stated that conflict between career interests and values of girls were possible explanations for their lack of representation in these fields. Encouragement of significant others was also cited as a reason for their lack of participation. Recommendations for educators and intervention programs were offered as possible solutions to the problem.

Friend, Harold. "The Effect of Science and Mathematics Integration On Selected Seventh Grade Students' Attitudes Toward and Achievement in Science" School Science and Mathematics 85 (1985): 453-461.

Friend wanted to determine what effects there are on science attitudes and achievement when a unified science/math approach was used. Four classes of seventh grade students were divided into two groups: those with standardized reading and math scores at least two years above grade level and those with standardized reading and math scores on grade level. The Science Attitudes Appraisal and the teacher made Test of Physics Facts and Principles were used to determine student attitudes and achievement. It was found that positive attitude change occurred only in the integrated on grade level group. However, an increase in science achievement occurred only in the integrated format and two years above grade level group. There was no significant increase in achievement in the other three groups. Also interesting to note was that the two years above grade level group taught by a nonintegrated format showed greater achievement gains than the integrated on grade level group of students. Friend concluded that an integrated science/math approach should be used with above average students.

Graham, Marilyn Fisher. "Sex Differences in Science Attrition." Diss. State University of New York at Stony Brook, 1978.

After a thorough review of the research available, Graham proposed four hypotheses to explain the lack of females participation in the sciences. Graham used students who were found to hold traditionally masculine views of science. Questionnaires were given in which students were asked about their prior science preparation, current science experiences and contacts with teachers, parents and peers, and about their expectations and plans regarding their science majors. It was found that females dropout rate in science was three times that of men. Graham also found that women dropped out of science regardless of their ability level or success in science. This study also confirmed previous research that women have less science and math preparation and extracurricular experiences compared to their male counterparts. The predicting factors that were found to determine those most likely to drop out of science were 1) students with low ability (low Math SAT scores), 2) students with low success in science courses, 3) females. An important point to note was that regardless of ability level and success females are more likely than males to drop science.

Graybill, Letitia. "Sex Differences in Problem-Solving Ability." Journal of Research in Science Teaching 12 (1975): 341-346.

The purpose of this study was to show the existence of gender differences in intellectual development and problem-solving ability. The procedure used was developed by Piaget and Inhelder. It involved a series of simple physics experiments. Children between the ages of nine and fifteen were asked to do four experiments and were evaluated as to whether they were in the formal or concrete stage of development. Graybill found that boys always appeared more confident in handling the equipment. Girls frequently asked for permission to do their work, while boys appeared to manipulate equipment with less direction. The greatest differences in logical thinking were found in the thirteen and fifteen year old group of students, differences in logical thinking first appeared at age eleven.

Haertel, Geneva D., Herbert J. Walberg, Linda Junker, and Ernest T. Pascarella. "Early Adolescent Sex Differences in Science Learning: Evidence from the National Assessment of Educational Progress." American Educational Research Journal 18 (1981): 329-341.

Information from the 1976 National Assessment of Educational Progress was used to identify sex differences in science achievement of adolescents. Analyses were done using as variables science learning, motivation, quality of instruction, class morale, peer influence, and home environment. There was found to be no existence of sex differences in early adolescent science learning, with the exception of motivation toward science. They found that as the parents level of education increased so did the boys motivation in science, but not the girls. In contrast to the sex factor, socioeconomic status and race both showed significant differences in most of the factors mentioned.

Handley, Herbert M., and Linda W. Morse. "Two-Year Study Relating Adolescents' Self-Concept and Gender Role Perceptions to Achievement and Attitudes Toward Science" Journal of Research in Science Teaching 21 (1984): 599-607.

Handley and Morse were interested in identifying the relationship between adolescents achievement/attitude in science and their perception of sex roles. They were also interested in discovering if these relationships increased as adolescents got older. In terms of achievement in science it was found that in seventh grade males self-concept and self-concept in science were positively related to achievement. It was also found that a negative correlation existed between girls achievement in science and their views of high expectations for males. The only significant difference was found in the negative correlation between males perception of themselves as risk takers and their achievement in science.

Harding, Jan. "Sex Differences in Science Examinations" The Missing Half: Girls and Science Education Manchester, England: Manchester University Press, 1981, 192-204.

Harding obtained data from the National Science Examinations and the Nuffield Science Teaching Project and observed that Nuffield Courses were being used more extensively for boys than girls. This study then investigated the reasons for the lack of attention given to girls. Six examinations were chosen for evaluation. Schools were identified as to single-sex or coeducational. Harding found that boys were more successful than girls in coeducational schools and girls in girls' (single-sex) schools were more successful than girls in coeducational schools. Harding concluded that two important dimensions which influenced girls' choice of science courses included their commitment to a career outside the home and sex bias of the career chosen. Harding proposed a four cell matrix which illustrates her conclusions.

Harty, Harold, Dwight, Beall, and Lawrence Scharmann. "Relationships Between Elementary School Students' Science Achievement and Their Attitudes Toward Science, Interest in Science, Reactive Curiosity, and Scholastic Aptitude." School Science and Mathematics 85 (1985): 472-479.

This study looked at the relationship between fifth graders science achievement and their attitudes toward science, interest in science, reactive curiosity and their scholastic aptitude. Student achievement was measured by the "Iowa Tests of Basic Skills - Science Supplement". Student attitudes were measured by the "Children's Interest in Science Measure" and curiosity was measured with the "Children's Reactive Curiosity Scale". Scholastic aptitude was measured with the "Cognitive Abilities Test: Multi-Level Form 3". The information showed that a relationship existed between science achievement and the predictor variables of attitudes toward science, interest in science, reactive curiosity, and scholastic aptitude. The greatest predictor was found to be scholastic aptitude.

Hasan, Omar E. "An Investigation into Factors Affecting Science Interest of Secondary School Students." Journal of Research in Science Teaching 12 (1975): 255-261.

The purpose of this study was to determine the influence of several selected variables (instruction, student, home and social) on students interest in science. A sample of eleventh grade students from secondary schools in Jordan were given a survey. Student interest was measured using a science interest scale. Comparisons were made between male and female high and low interest students. It was found that variables dealing with instruction, outer motivation, and inner motivation, differentiated significantly for males. A significant difference between female high and low interest students was found in the areas of outer motivation and inner motivation. Specifically for females differentiating significantly were the variables associated with career desired by parents, career desired by student, and the student's ability in science.

Kahle, Jane Butler. "Girls in School/Women in Science: A Synopsis." Paper presented at the Annual Women's Study Conference, 1984. (ERIC Document ED 243 785)

Following a review of the research literature, Kahle used the information provided by the 1977 and 1982 National assessment of Educational Progress to identify the factors associated with the misrepresentation of women in the field of science. Kahle identified three types of factors which influence girls choices in science, 1) social, 2) educational, and 3) personal. Kahle stressed that the place which needed to be closely investigated was the science classroom. Kahle also identified ten teaching behaviors which resulted in more girls staying in science.

Kahle, Jane Butler, and Marsha K. Lakes. "The Myth of Equality in Science Classrooms." Journal of Science Teaching 2 (1983): 129-140.

An analysis was done of the Third National Assessment of Science. The survey of science attitudes showed that by age nine females express desire to participate in science but are extremely limited in their experiences. The information also showed that girls have fewer opportunities to use scientific apparatus. The lower enrollment of females in mathematics and physical science classes also limits females in their pursuit of science careers. Kahle and Lakes also suggested that teacher expectations, as well as stereotyping of careers, may deter girls from science. Changes in classroom instruction and parental expectations, as well as participation in science activities are suggested as possible solutions to the inequalities present in the science classroom.

Kelly, Alison. "Why Do Girls Study Biology." School Science Review 56 (1975): 628-632.

The assumption was made by Kelly that girls choose biology over the physical sciences because of it's nurturative nature. A random sample of university students were then asked to indicate on a scale how strongly they agreed or disagreed with the statement "my ideal job would give me an opportunity to work with people rather than things". It was found that women in general place a greater importance on working with people than men do. However, when Kelly looked at individual subject groups the difference disappeared. In general, all science students, both male and female, showed an indifference. Thus it was suggested that girls choose science because of social and educational factors.

Keys, Wendy, and M.B. Ormerod. "A Comparison of the Pattern of Science Subject Choices for Boys and Girls in the Light of Pupils Own Expressed Subject Preferences." School Science Review 58 (1976): 348-350.

This study was designed to look at boys and girls actual choices of science subjects compared to their actual subject preference. The science subjects specifically looked at were: chemistry, physics, and biology. It was found that a large number of girls choose biology compared to boys and that a high percentage of these girls do not particularly like biology. The study showed the same results for boys in physics classes. It was also found that a significant proportion of girls who like both chemistry and physics were dropping these courses. The findings from this study suggested that there must be other variables present which influence students choices of science classes.

Khoury, Ghada A., and Burton E. Voss. "Factors Influencing High School Students Science Enrollment Patterns: Academic Abilities, Parental Influences and Attitudes Toward Science." Paper presented at the Annual Meeting of The National Association for Research in Science Teaching, 1985, ERIC Document ED 254 408.

A closer look at the reasons for which students give for choosing specific science classes was the purpose of this study. Khoury and Voss wanted to identify those characteristics and relationships that exist when high school students are selecting science courses. After reviewing the literature they found that factors such as past achievement, sex, parental support, teacher support, and attitudes toward science are important factors relating to students decisions concerning future science courses. A path analytical model was proposed. The study was then conducted to determine how well the factors in the model related to students choices. They also set out to answer questions concerning the disproportionate ratio of male to female students in science classes. A questionnaire was developed. The survey contained two parts. The first part collected demographic and socioeconomic information about the students. The second part was divided into twelve different subscales measuring students attitudes in several areas. Several patterns and trends were identified concerning enrollment in future science courses. The research also showed a distinct difference in the plans of male and female students.

Lansdell, Herbert. "A Sex Difference in Effect of Temporal Lobe Neurosurgery on Design Preference." Nature 194 (1962): 852-854.

Lansdell worked at the National Institute of Health with patients who suffered from brain damage. He studied the effects of the removal of part of the temporal lobe in his patients. This removal was done to help alleviate epileptic seizures. After reviewing other literature he predicted that removal of part of the right hemisphere would result in a decrease in spatial visualization skills and a removal of the left hemisphere would result in a decrease in verbal skills. After he gathered information concerning his patients performance on tests of spatial visualization and verbal skills, he found that his predictions were correct, but only for his male patients. He therefore concluded that males were more lateralized than females.

Lawrenz, Frances P., and Wayne W. Welch. " Student Perceptions of Science Classes Taught by Males and Females." Journal of Research in Science Teaching 20 (1983): 655-622.

Lawrenz and Welch used the Learning Environment Inventory (LEI) to look more closely at the effects of the classroom environment on the science classes which females choose. Teachers from fourteen different states and science classes ranging from junior high science through high school physics were used in the study. Each of the 334 teachers selected one of their classes to give the survey to. Using the two-way multivariate analysis of variance, Lawrenz and Welch found no significant interaction between teacher gender and the type of class. This meant that the effect of teacher gender could be used in all classes. A univariate analysis of each class was done. Six of the LEI scales were found to have a significant effect on females class choices. The six scales were diversity, formality, friction, goal direction, favoritism, and difficulty. Of the six just mentioned only in difficulty were male teachers perceived higher than female teachers. The other five areas were perceived to be characteristic of female classrooms. Therefore it was concluded that students in science classes do perceive their environment differently when the class is taught by a male or female.

Lazarowitz, Reuven, and Rachel Hertz Lazarowitz. "Choices and Preferences of Science Subjects by Junior High School Students in Israel." Journal of Research in Science Teaching 16 (1979): 317-323.

This study looked at Israeli Junior High School students' choice of science classes and what their preference was for science classes. Background research was cited that showed that in the past students exhibited a definite preference for certain science subjects. At the end of the school year the students were asked to list their choices with their first choice (preference) listed first. The top three choices were zoology, human body, and human life. The top three preferences were human body, zoology, and electricity. The information was also summarized according to grade, gender, and school affiliation (religious or secular). Definite trends were found to exist in these variables. Zoology was found to decrease in preference from grades seven to nine, while preference for human body increased. In general, those subjects which were found to be part of the curriculum from grade seven to nine decreased and those subjects not included in the curriculum increased in preference. Sex differences found female preferences to be in the "soft biological subjects" such as plants, animals, and human life. Males tended to prefer electricity. Religious differences showed a trend for students of religious schools to prefer the studies involving human obdy and human life. The pattern of religious students was very similar to that trend found for females.

Lederman, Norman G. "Relating Teaching Behavior and Classroom Climate to Changes in Students Conceptions of the Nature of Science." Science Education 70 (1986): 3-19.

Two years of research was done to determine the classroom variables which are found to be related to changes in high school students conceptions of the nature of science. The research took place in five stages. The first three stages were conducted and the classes were divided into two group with six classes representing those classes which showed the greatest change from the pretest to post-test (high) and six classes representing those classes which showed the least change from the pretest to post-test (low). Stage four and five were then conducted with these two groups. Lederman found that teachers and classrooms where the greatest change took place were typically more pleasant, supportive, and more open to student input. Teachers in classrooms where the greatest change took place also asked higher level questions and used a problem solveing approach.

Levitin, Teresa E., and J.D. Chananie. "Responses of Female Primary School Teachers To Sex-Typed Behaviors in Male and Female Children." Child Development 43 (1972): 1309-1316.

Levitan and Chananie proposed that teachers expect males to demonstrate aggressive behavior and females to demonstrate dependency and their study tested this hypothesis. Forty first and second grade teachers were given a questionnaire and then asked to evaluate a hypothetical child based on a description of the childs behavior. It was found that the children which were described as behaving in an appropriate sex-typed way were found to be more typical than those who were described in an inappropriate way. It was also found that dependent behavior was signfificantly found to be more desired than aggresive behavior. In terms of the teachers liking the children it was found that the dependent girl was found to be more acceptable than the aggressive girl. However, there appeared to be no difference between the acceptance of the dependent boy and the aggressive boy. Levitan and Chananie found that achievement behavior was the most preferred behavior regardless of sex.

Lowery, Lawrence F. "An Experimental Investigation Into the Attitudes of Fifth Grade Students Toward Science." School Science and Mathematics 67 (1996): 569-579.

Lowery measured the attitudes of fifth grade students toward science. He was especially interested in the attitudinal changes that would take place after the students completed a discovery learning unit on animal coloration. Lowery looked not only at the changes in attitude following the new curriculum material, but also at the differences in attitude that existed amongst different socioeconomic levels, different sexes, different IQ's, and different knowledge levels. Lowery conducted both a statistical and descriptive analysis of the data on both the pretest and post-test. On the pretest he found that several of the attitudes were the same for children in both the experimental and control group. Children in upper socieoeconomic brackets had a more positive attitude toward science. The pretest also showed that girls attitudes towards science were significantly more positive than boys. Post-test results showed that the experimental group, which received instruction through the coloration unit, increased their positive attitude, the control group did not. The attitude scores of all the students in all socieoeconomic levels of the experimental group increased, there was no significant gain in the control group. The boys in the experimental group showed a greater gain than the girls. The positive gain by the boys brought the attitudes of both boys and girls to the same level. Lowery concluded that the animal coloration unit (discovery learning) positively changed the attitudes of fifth grade students. The survey also presented many new findings concerning students attitudes toward science.

Maccoby, E.E., and C.N. Jacklin. "Intellectual Abilities and Cognitive Styles." The Psychology of Sex Differences, Stanford: The Stanford University Press, 1974, 63-133.

Maccoby and Jacklin cited several research studies as well as their own work, to explain those variables responsible for the differences in cognitive abilities of males and females. They found that there appeared to be no significant difference in the overall IQ scores of males and females. However, when they looked at subtests it was revealed that females were superior to males in verbal ability and males were superior to females in spatial visualization abilities and math aptitude. These differences in specific abilities begin during early adolescence. Evidence for these differences has been linked to genetic inheritance, hormonal influence, and differential brain development, but no conclusions have been drawn from this inconclusive research.

Maehr, Martin L. "On Doing Well in Science: Why Johnny No Longer Excels; Why Sarah Never Did." In S. Paris, G. Olson, and H. Stephenson (Eds.) Learning and Motivation in the Classroom. Hillsdale, NJ: Lawrence Erlbaum and Sons. 1983. 179-208.

After offering evidence that science achievement has declined over the last several years, Maehr proposed possible explanations and solutions to remedy this problem. Two quick solutions, offer more science and demand more from students, were shown to be inadequate solutions to the problem. A third solution was offered which dealt with improving students motivation to achieve in science. Maehr identified the motivational characteristics that are present in students who achieve well in science. He stated that scientifically oriented people need to operate under both task and ego goal conditions. Maehr also stated that one reason for the gender differences that appear in science is the fact that males and females have different goal orientations. Maehr concluded that science should be taught under task goal conditions.

McGarity, John R., and David P. Butts. "The Relationship Among Classroom Management Behavior, Student Engagement, and Student Achievement of Middle and High School Students of Varying Aptitude." Journal of Research in Science Teaching 21 (1984): 55-61.

The main objective of this study was to look at the specific factors which influence successful science achievement. The factors looked at were teacher management and student participation and their relationship to science achievement. Thirty junior high and high school teachers along with 672 students were involved in the study. Classroom management behavior was measured with the Teacher Performance Assessment Instrument (TPAI). From the TPAI twelve factors were identified as important in classroom management. SAT scores were used as measurement of student achievement. Observations were made of each classroom to measure student engagement. It was found that 1) teachers classroom management was positively related to both student engagement and student science achievement, 2) student engagement is also positively related to student achievement, and 3) high aptitude students spend more time engaged in academic activities. McGarity and Butts concluded that the classroom that is well managed and easy for the learner to pay attention while the task is being taught will show student achievement.

McGlone, Virginia. "Improving Ninth Grader's Algebra Achievement -- The Key to Future Success in Mathematics and Science -- Through an Intensive Workshop Intervention Experience. Final Report." ERIC Document, 1985, ED 259 899.

Underachieving female students participated in a five part workshop, with seventeen students in each workshop. The goal of the project was to significantly affect the algebraic achievement and attitudes of the participants towards mathematics and science. One of the main interventions was to prcvide female role models, both instructionally and with a panel of professionals. McGlone found improvements in atttitude, achievement and self-confidence in this group of underachieving females.

Montemayor, Raymond. "Children's Performance in a Game and Their Attraction to it as a Function of Sex-typed Labels." Development 45 (1975): 152-156.

Montemayor wanted to determine whether children would perform better on an activity that was labeled sex-appropriate or an activity that was labeled sex-inappropriate. Sixty boys and girls between the ages of six and eight were asked to play with a toy, the varying factor was that some were told it was a toy for their sex and others were told it was a toy for the opposite sex. Montemayor found that performance was highest when the toy was labeled as sex-appropriate, intermediate when no label was given, and lowest when the toy was labeled sex-inappropriate.

Pascarella, Ernest T., Herbert J. Walberg, Linda K. Junker, and Geneva D. Haertel. "Continuing Motivation in Science for Early and Late Adolescents." American Educational Research Journal 18 (1981): 439-452.

Continuing motivation shows a willingness of students to carry beyond the classroom the learning activities which they have participated in. The study by Pascarella, et.al., looked at the specific characteristics of classrooms that encourage continuing motivation in early and late adolescents. The authors chose four specific classroom characteristics which were looked at: class morale, utility of science content and science classes, teacher encouragement, and teacher control. Not only did they look at how the environment affected continuing motivation, but also at its affects on different students. Information from the National Assessment of Educational Progress was used in the study. The researchers found that there were two classroom characteristics that had a positive effect on continuing motivation. They were class morale and content of science classes. Teacher control and structure of classroom activities had a negative effect on continuing motivation. The study did show that teacher control was positively related to science achievement. Also, it was found that as the students level of achievement decreased so did the positive relationship between continuing motivation and their ability to use science. The same was found for class morale.

Peng, Samuel S., and Jay Jaffe. "Women Who Enter Male-Dominated Fields of Study in Higher Education." American Educational Research Journal 16 (1979): 285-293.

Peng and Jaffe looked at sixteen variables which were divided into six categories to determine their influence on women's entry into male-dominated fields. Information obtained from the National Longitudinal Study of High School Class of 1972 was used in this research. It was found that high school experience, academic ability, life goals and educational plans are all important predictors in determining females entry into male-dominated fields. High school experience was found to be an important predictor for both males and females. Peng and Jaffe also determined that one of the strongest predictors for females was their experience in high school science courses.

Petersen, Anne C. "Physical Androgyny and Cognitive Functioning in Adolescence." Developmental Psychology 12 (1976): 524-533.

The purpose of this study was to determine whether spatial visualization and verbal ability (fluent production) are related to the presence of sex hormones. A canonical correlation was used to test the relationship between variables and the physical hormones. The correlation was significant for both males and females at ages sixteen and eighteen. The results suggested that male hormones feminize performance among males. In females, those with low estrogen levels (less mature) also demonstrated higher spatial visualization skills.

Smith, Walter S., Norma I. Frazier, Sharon Ward, and Mildred Webb. "Early Adolescent Girls' and Boys' Learning of a Spatial Visualization Skill - Replications." Science Education 67 (1983): 239-243.

The authors sought to replicate the results of a study done by Smith and Litman in 1979 dealing with the effects of instruction and its relationship to spatial visualization skills in early adolescents. The results of the experiment showed that there was no significant interaction between the effect of sex on spatial visualization skills. Instruction was found to have a positive effect. Thus it was concluded that instruction does not have a differential effect on the spatial visualization skills of early adolescent boys and girls.

Stein, Aletha Huston, Sheila Rimland Pohly and Edward Mueller. "The Influence of Masculine, Feminine, and Neutral Tasks on Children's Achievement Behavior, Expectancies of Success, and Attainment Values." Child Development 42 (1971): 195-207.

Stein, Pohly, and Mueller wanted to verify other research that showed that children's sex-role perception of a task effects their performance on that task. Sixth grade boys and girls were given a written test presented to them as macsuline, feminine, or neutral. The results of the study demonstrated that the sex-typed labeling of a task influences achievement motivation. It also was found that the effects of sex-typed labels are stronger for boys than for girls. Stein, Pohly, and Mueller offered as an explanation for the difference between boys and girls, the sociological influence of parental and societal pressure on boys to achieve in a sex appropriate manner.

Steinkamp, Marjorie W., and Martin L. Maehr. "Gender Differences in Motivational Orientations Toward Achievement in School Science: A Quantitative Synthesis." American Educational Research Journal 21 (1984): 39-59.

This article contained a comprehensive review of the literature dealing with motivation and achievement in science of both boys and girls. It was found that differences do exist in both motivation and achievement. The literature contained twenty-five variables thought to affect motivation in science. Generally, it was found that science areas that deal with outside experiences are favored more by boys, and the general motivation of boys begins to surpass their female counterparts during early adolescence. Of even greater concern was the fact that gender differences occured the most in technologically advanced countries.

Steinkamp, Marjorie W., and Martin L. Maehr. "Affect, Ability and Science Achievement: A Quantitative Synthesis of Correlational Research" Review of Educational Research 53 (1983): 369-396.

In an attempt to sort through a large body of information Steinkamp and Maehr conducted a quantitative synthesis of the studies from 1965 to the present that dealt with science achievement, affect and ability. Sixty-six studies were used that provided 255 correlations. Gender-achievement correlations showed boys achieved slightly higher than girls. Gender-cognitive ability correlations were also found in favor of males. Gender-affect correlations were only found to affect junior high age males. It was also found that higher levels of cognitive ability are positively related to higher levels of science achievement for both boys and girls. A small relationship was found between achievement and affect, with this relationship found to be somewhat stronger for early high school females. No relationship was found to exist between cognitive ability and affect.

Thomas, Gail E. "Cultivating the Interest of Women and Minorities in High School fMathematics and Science." Science Education 70 (1986): 31-43.

This study was done to identify what factors influenced students interests in math and science. Thomas also wanted to find out if there were differences between the factors influencing males and females. It was found that having an interest in science hobbies during childhood has a positive relationship and is more strongly related to students' interest in science than any of the variables. The next three most important factors were receiving encouragement from significant others, having held childhood aspirations of being a scientist, and standardized test performance. A separate analysis was done comparing males and females. As stated previously, an interest in science hobbies had the strongest influence on both males and females. The next two most important factors for females were receiving encouragement and performance on standardized tests. For males, childhood aspirations of being a scientist and high school grades were second most important. It was also found that having high occupational expectations had a significant effect on science interest for males.

Treagust, David F. "Gender-Related Differences of Adolescents in Spatial Representational Thought." Journal of Research in Science Teaching 17 (1980): 85-91.

Treagust proposed that a genetic explanation can be used to account for the gender differences in ability in both math and science. Treagust ascertains that "the development of infralogical groupings is a prerequisite to a functional knowledge" of certain aspects of math and science. Therefore, the purpose of the study was to find out if a relationship existed between performance and gender on six tasks designed to measure infralogical spatial grouping ability. There was a significant difference in performance of males and females on four of the six tasks. Treagust concluded that based on the lack of evidence of gender differences in elementary school, a genetic explanation best explains the results.

Vockell, Edward L., and Susan Lobonc. "Sex-role Stereotyping by High School Females in Science." Journal of Research in Science Teaching 18 (1981): 209-219.

Vockell and Lobonc sought to answer two questions in this study, 1) Is there a difference in the way male and female high school students perceive the physical sciences? and 2) What effect do coeducational classes have on these perceptions? The study involved a questionnaire asking students to rank forty-five different subject areas as masculine or feminine. The results showed that females did consider the physical sciences to be more masculine than the biological sciences. The study also showed that non-coed girls found the physical sciences to be less masculine than coed girls. Vockell and Lobonc concluded that the presence of males in physical science classes may lead to competition and the the stereotyping of the physical sciences.

Waber, Deborah P. "Sex Differences in Mental Abilities, Hemispheric Lateralization, and Rate of Physical Growth at Adolescence." Developmental Psychology 13 (1977): 29-38.

Waber's study investigated the general hypothesis that physical growth (maturation) was a determinant of behavioral sex differences. Since girls mature earlier than boys, they are considered in this study to be the early-maturing individuals. Three specific hypotheses were tested. It was found that late-maturers did not perform better on verbal tasks. Early-maturers were found to perform better on verbal tasks than spatial and late-maturers performed better on spatial tasks than verbal. However, since verbal ability was found to not be related to maturation rate the outcome was determined to be due to the spatial differences present. Late-maturers also showed greater brain lateralization for speech perception than early-maturers, but only in the twelfth grade group.

Ware, Norma C., Nicole A. Steckler, and Jane Lesserman. "Undergraduate Women: Who Chooses a Science Major?" Journal of Higher Education 56 (1985): 73-84.

Ware, Steckler, and Lesserman selected 300 freshmen science majors with equal mathematical ability, level of preparation and interest, who answered questionnaires, one before entering college and once each year during college. The purpose of their investigation was to find out why women science prospects abandon their career plans. A multiple regression analysis revealed that different factors were predictors for male and female students. The factors which were significant predictors of a science major for women were; 1) parents were highly educated, 2) need high mathematics scores on the SAT, 3) strong desire for control, prestige, and influence, and 4) need for affiliation. Significant predictors for men were; 1) high grades in freshmen science courses and 2) being certain of their choice for a major the summer before college. A significant predictor for both sexes was enjoyment of a science course more than other courses during their freshmen year.

Witelson, Sandra F. "Sex and the Single Hemisphere: Specialization of the Right Hemisphere for Spatial Processing." Science 193 (1976): 425-427.

Witelson conducted a study which involved the dichaptic stimulation test with a group of young children between the ages of six and thirteen who were strongly right-handed. Witelson found that there was a significant interaction between handedness and sex. Boys left-hand score was found to be better than their right-hand score. However, no difference was found for girls. Witelson's study suggested that sex differences in lateralization occur very early in development and once again confirmed that boys were more lateralized than girls.

SUMMARY

A simple solution to the problem of the lack of participation of females in the field of science does not exist. Several variables were found which influenced the career choices of females. The research studies which have been investigated in this project proposed several personal (biological, individual self-concept and locus of control), social (stereotyping and influence of significant others), and educational (classroom environment and science experience) factors which are responsible for this lack of female participation in the sciences.

Most of the research which dealt with biological influences and cognitive ability was very inconclusive. What made this a difficult area to draw conclusions from was that when differences in cognitive ability between the sexes were present they were very small, yet very consistent. As Steinkamp and Maehr (1983) pointed out, even though these differences are small it may be this small percentage that is the cut off point for admittance into special schools. Therefore, this variable has undergone further research.

Maccoby and Jacklin (1974) found that the general IQ scores of males and females were very similar. However, when subtests were looked at cognitive differences began to appear during early adolescence. They found that females tended to score higher on tests of verbal ability and males tended to score higher on tests of mathematical ability and spatial visualization tasks. The possibility of an X-linked gene for spatial ability has been offered as one explanation of this difference between the sexes.

Bock and Kolakowski (1973) found that spatial visualization skills are inherited in a typical recessive X-linked gene pattern. Benbow and Stanley (1980) also made claims that supported this explanation. This inheritance of spatial visualization ability in the typical X-linked manner has caused many researchers and educators to conclude that males have an inherited math advantage over females.

Also biologically based was the explanation that spatial visualization skills are influenced by sex hormones. Generally, it was found that late-maturing adolescents performed better on spatial visualization tasks than their more mature peers.(Petersen 1973, Waber 1977) This research suggested that high levels of the male hormone (androgen) and the female hormones (estrogen and progesterone) have a negative effect on spatial visualization skills. This area of hormonal influence has not been reasearched as thoroughly as the X-linked explanation, partially due to the difficulty of measuring the affects of adolescent hormone levels.

Brain lateraliztion has also been offered as a biological explanation for spatial visualization differences that exist between males and female. Lansdell (1962) was the first to suggest this explanation. He found that damage to the left hemishpere of the brain resulted in a decrease in ones ability to perform spatial visualization tasks. Lansdell also noted that damage to the right hemisphere resulted in a decrease of verbal ability. What made Lansdell's research interesting was that these difference occurred only in males. This research suggested

that males spatial ability and verbal ability are located in separate specific cerebral hemispheres, while females are more bilateral. Witelson (1976) showed that this lateralization of males occurs at a very early age. Waber's (1977) research showed that late-maturers also demonstrated more brain lateralization than early maturers. Waber's research supported earlier research which demonstrated that lateralization was important in the development of high spatial visualization skills. The question still remains unanswered as to whether or not there is a biological explanation for these cognitve differences between the sexes.

An individual's self-concept has also been shown to be related to science achievement and students attitudes toward science. Handley and Morse (1984) found that as girls went from seventh to eighth grade their general self-concept and achievement in science became "significantly less positive". (Handley and Morse p. 606) This research suggested that science achievement during the early junior high school years is important for females to maintain a positive self-concept about their ability in science. Doran and Sellers (1978) also found that a high level of science achievement correlates positively with a positive self-concept in science. Following their examination of the results from the NAEP, Alvord and Glass (1974) suggested that students self-concept concerning their achievement in science is a strong predictor of their future achievement in science.

Locus of control also has an adverse effect on females science achievement. Females were found to explain their poor performance in a difficult class on their own inadequacey.(Ware, et.al. 1985) Females also were found to attribute their success to luck. Those who attribute success in this way are likely not to pursue that area in which they have just succeeded.(Maehr 1983) The fact that females are found to be more external for success in science and internal for failure in science is representative of an individual with a low self-concept. A low self-concept has already been related to low achievement. Graham (1978) suggested that since women attribute their science difficulties to a lack of ability this may explain their lack of "perserverance" in science courses.(Graham 1978, p.32)

Sociologically, stereotyping has been found to have adverse effects on females attainment of science careers. Females have been found to perceive science as a male domain.(Vockell and Lobonc, 1981) A females perception of science as a masculine or feminine was found to effect her attitude and achievement in science. Montemayer (1975) found that both sexes perform better on a task which is labeled sex-appropriate. Stein, Pohly, and Mueller (1971) also found that females had higher attainment values and expectancies of success when a task was labeled feminine or neutral. Females have also shown that they consider science to be a masculine field by the science subjects which they have chosen.(Baird,et.al. 1984, Keys and Ormerod, 1976) Researchers have offered as an explanation to this sociological trend the imbalance that occurs in coeducational science

classrooms. They have suggested that the high ratio of males to females in upper level science courses creates a competition and an unfeminine atmosphere which deters females from these science course.(Eshiwani 1983, Harding 1981)

Vockell and Lobonc (1981) have also suggested that the perception of the sciences as a masculine endeavor may be due to the lack of upper level female science instructors. These conclusions were drawn from the data which demonstrated that girls in all-girl schools do not percieve science to be as masculine as girls from coeducational settings. One explanation offered for this perception by non-coed girls was the fact that they are exposed to more female science teachers. They also do not experience any male competition in science classes.

Lawrenz and Welch (1983) also conducted research on students perception of classes taught by males and females. They found that classes taught by females tended to be more formal, goal directed, and diverse. They also found that female teachers displayed more favoritism and their classrooms exhibited more friction between students. Several of these characteristics carried with them negative effects on the outcomes of science. Vockell and Lobonc (1981) suggested that even though female role models may be present in science classrooms there are negative outcomes which may be stronger than the positive presence of a female role model.

Educationally there are many factors which have been found to have adverse effects on the females pursuit of science. Classroom management is one variable that was found to be

positively related to science achievement.(McGarity and Butts 1984, Pascarella et.al. 1981) Lederman (1986) found that classrooms where science teachers were highly successful in motivating students had the following similarities, "inquiry questioning, problem-solving, and student-teacher interactions". "Seat-work and rote-memory were less typical" of the classes with successful teachers.(Lederman p. 14) This research demonstrated the importance of the classroom environment not only in the science achievement of females, but of all students.

Classroom teachers have also been shown to have different expectations of girls and boys classroom performance. Benz, Pfeiffer and Newman (1981) found that a masculine sex type carried with it the high-achiever label. High-achievement was found to be negatively related to a feminine sex role. The conclusion of their study was that "to fit the feminine role is not to achieve".(Benz, et.al. p. 297) Research has also shown that teachers prefer a high achieving dependent girl as a student.(Levitan and Chananie 1972) This breeding of the perfect female student as being dependent will contradict the characteristics that are looked for in science achievement.

Many researchers have also suggested that one reason girls are under-represented in science is due to their lack of experience.(Fox, 1976; Graham, 1978; Kahle and Lakes, 1983) Thomas (1986) found that having an interest in science hobbies had a strong positive effect on interest in high school science for males and females. Erickson and Erickson (1984) also suggested that "different experiences (e.g. different toys,

hobbies pursued, games that are played) contribute to providing boys with more relevant experiences upon which they can draw from in science classes".(p. 76) From the research reviewed it can be concluded that science is more in the realm of boys experiences.

CONCLUSION

As has been evidenced by the research, there are many variables which may influence the retention of females in the field of science. It is important for educators and parents to be aware of the importance that their actions may play in the development of female scientists. Extracurricular experience and the encouragement of significant others are both strongly related to females pursuit of science. Both of these factors begin to influence females very early in their development. Experience and encouragement are two factors that parents and educators can easily control.

RECOMMENDATIONS

Research has offered many suggestions as to how we can improve our home and educational environment in order to encourage more girls towards pursuing science in the future. Starting first with preschool girls at home. It is important that parents provide their daughters with toys and activities that are similar to those they would provide for their sons. Young girls should be encouraged to play with blocks and other types of building toys. Girls should also be provided with puzzles and other objects to help improve their problem solving skills.

Once girls enter school the socialization process begins to take place. Girls are expected to do girl acitivities and boys are expected to do boy activities. Teachers need to be aware of the stereotypical behaviors that occur. Young children are naturally curious about the world around them. When a young

girl shows interest in how something works or why objects behave in the way they do, teachers need to encourage this natural curiosity and not discourage it.

Junior high school appears to be the most crucial time for intervention to begin. Research shows that it is at this time, early adolescence, when the distance between boys and girls really begins to widen. During these years boys and girls begin to become aware of their sex roles and what society feels are appropriate roles for each sex. There are many factors which play a part in influencing what a female determines to be sex appropriate. As educators, we can provide females with an equal opportunity to use equipment and participate in problem solving activities. During these years group activities (such as laboratory activities in science classes) should involve single sex groups. Avoiding mixed grouping will help decrease the competition between boys and girls. Single sex groups will also provide females with an opportunity for comradeship in science.

Career guidance becomes very important as females enter high school. Counselors need to identify those girls with high SAT scores in math, a high level of science achievement, and a positive attitude toward science and encourage them to continue with a math/science curriculum. During high school females also need to be provided with professional role models. This can be done through an extracurricular function or provided by classroom teachers. Since high school is the time when students begin to elect courses, administrators need to be aware of the ratio of males to females in upper level science courses. Scheduling

should be carefully planned so that classes have an equal representation of males and females.

If, as parents and educators, we provide early experiences for females and also pay close attention to the environmental factors, we will be able to increase the participation of females in the science world.

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